From the Society for Clinical Vascular Surgery

Adherence to postoperative surveillance guidelines after endovascular aortic aneurysm repair among Medicare beneficiaries

Trit Garg, BA,[a] **Laurence C. Baker, PhD,**[b,c] and **Matthew W. Mell, MD, MS,**[a] *Stanford, Calif; and Cambridge, Mass*

Objective: After endovascular aortic aneurysm repair (EVAR), the Society for Vascular Surgery recommends a computed tomography (CT) scan ≤30 days, followed by annual imaging. We sought to describe long-term adherence to surveillance guidelines among United States Medicare beneficiaries and determine patient and hospital factors associated with incomplete surveillance.
Methods: We analyzed fee-for-service Medicare claims for patients receiving EVAR from 2002 to 2005 and collected all relevant postoperative imaging through 2011. Additional data included patient comorbidities and demographics, yearly hospital volume of abdominal aortic aneurysm repair, and Medicaid eligibility. Allowing a grace period of 3 months, complete surveillance was defined as at least one CT or ultrasound assessment every 15 months after EVAR. Incomplete surveillance was categorized as gaps for intervals >15 months between consecutive images as or lost to follow-up if >15 months elapsed after the last imaging.
Results: Our cohort comprised 9695 patients. Median follow-up duration was 6.1 years. A CT scan ≤30 days of EVAR was performed in 3085 (31.8%) patients and ≤60 days in 60.8%. The median time to the postoperative CT was 38 days (interquartile range, 25-98 days). Complete surveillance was observed in 4169 patients (43.0%). For this group, the mean follow-up time was shorter than for those with incomplete surveillance (3.4 ± 2.74 vs 6.5 ± 2.1 years; $P < .001$). Among those with incomplete surveillance, follow-up became incomplete at 3.3 ± 1.9 years, with 57.6% lost to follow-up, 64.1% with gaps in follow-up (mean gap length, 760 ± 325 days), and 37.6% with both. A multivariable analysis showed incomplete surveillance was independently associated with Medicaid eligibility (hazard ratio [HR], 1.42; 95% confidence interval [CI], 1.29-1.55; $P < .001$), low-volume hospitals (HR, 1.12; 95% CI, 1.05-1.20; $P < .001$), and ruptured abdominal aortic aneurysm (HR, 1.51; 95% CI, 1.24-1.84; $P < .001$).
Conclusions: Postoperative imaging after EVAR is highly variable, and less than half of patients meet current surveillance guidelines. Additional studies are necessary to determine if variability in postoperative surveillance affects long-term outcomes. (J Vasc Surg 2015;61:23-7.)

The treatment of abdominal aortic aneurysms (AAAs) has shifted from open surgical repair to endovascular aortic aneurysm repair (EVAR) in recent years.[1] Although EVAR has been associated with greater perioperative survival compared with open surgical repair, significant concerns remain regarding the long-term durability of the repair.[2-4] Persistent aneurysm enlargement and potential rupture can occur after EVAR, and patients are therefore advised to undergo lifelong surveillance after EVAR.[2-5] The Society for Vascular Surgery (SVS) recommends computed tomography (CT) scanning at 1 and 12 months during the first postoperative year, with an additional CT at 6 months if an abnormality is detected at the first month. After the first year, CT scanning is recommended every 12 months, with the alternative option of ultrasound imaging if no abnormality was detected during the first year.[5]

Notwithstanding these guidelines, several single-institutional studies suggest that only a minority of patients receive the recommended life-long surveillance after EVAR.[6-8] These studies, however, may underestimate the true adherence to surveillance guidelines because patients may relocate or receive surveillance imaging from other hospitals. We used Medicare claims data to describe long-term adherence to SVS surveillance guidelines in actual practice and determine patient and hospital-level factors associated with complete and incomplete surveillance.

METHODS

This study was approved by the Stanford University School of Medicine Institutional Review Board, with a waiver of consent because the study was retrospective and the data used did not contain patient names or other contact information.

From the Division of Vascular Surgery[a] and Department of Health Research and Policy,[b] Stanford University School of Medicine, Stanford; and the National Bureau of Economic Research, Cambridge.[c]
Author conflict of interest: none.
Presented as a poster at the Forty-second Annual Symposium of the Society for Clinical Vascular Surgery, Carlsbad, Calif, March 18-22, 2014.
Reprint requests: Matthew W. Mell, MD, MS, Division of Vascular Surgery, 300 Pasteur Dr, Ste H3600, Stanford, CA 94305 (e-mail: mwmell@stanford.edu).
The editors and reviewers of this article have no relevant financial relationships to disclose per the JVS policy that requires reviewers to decline review of any manuscript for which they may have a conflict of interest.
0741-5214

http://dx.doi.org/10.1016/j.jvs.2014.07.003

Data sources. We used a 20% sample of Medicare fee-for-service claims data from 2002 to 2011. The Medical Provider and Analysis Review (MedPAR, part A) files and physician Carrier (part B) files were used to identify inpatient claims by hospitalizations and physicians services that were billed, respectively. All diagnoses and hospital procedures from the MedPAR (part A) files were identified using the International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) codes found as part of each inpatient claim. Similarly, Current Procedure Terminology (CPT) codes (American Medical Association, Chicago, Ill) were used to identify physician procedures from the Carrier (part B) files. The Medicare denominator and beneficiary summary files were used to collect demographic, Medicare enrollment information, and mortality data.

Patient events. Our cohort consisted of patients who underwent AAA repair with EVAR between January 1, 2002, and December 31, 2005, without perioperative mortality, defined as death at discharge or ≤30 days of surgery. Patients were identified using an ICD-9-CM diagnosis code for intact (441.4, 441.9) or ruptured (441.3, 441.5) AAA, as well as an ICD-9-CM procedure code for AAA repair (38.34, 38.44, 38.64, 38.92, 39.71). The date of AAA repair was recorded as the index date.

Patients aged <65 years on the index date were excluded. Also excluded were patients with enrollment in a health maintenance organization (HMO) or those with incomplete Medicare part A or part B coverage because claims for these patients might be incomplete. We defined the follow-up period as the duration between the date of the surgery and the date of censoring: HMO enrollment, incomplete Medicare part A or part B coverage, or death at any time during the follow-up.

During the follow-up period, all postoperative imaging data were collected using CPT codes for ultrasound imaging (76770, 76775, 93975, 93976, 93978, 93979) and CT (72191, 72192, 72193, 72194, 74150, 74151, 74152, 74153, 74154, 74155, 74156, 74157, 74158, 74159, 74160, 74161, 74162, 74163, 74164, 74165, 74166, 74167, 74168, 74169, 74170, 74171, 74172, 74173, 74174, 74175, 74176, 74177, 74178, 74261, 74262, 74263, 75635) of the abdomen. Multiple codes of the same imaging modality on the same date were counted as one postoperative surveillance imaging examination.

Allowing a grace period of 3 months, we defined complete surveillance as one imaging event ≤15 months of repair and at least one imaging event every 15 months thereafter. We categorized incomplete surveillance as a gap in surveillance if the interval between images was >15 months, and loss to follow-up if the censor date was >15 months from the date of the last imaging event.

Other measures. The Medicare denominator and beneficiary summary files were used to record age, sex, race, and Medicaid eligibility status. The U.S. Department of Agriculture census-based Rural Urban Commuting Area (RUCA) codes were used to categorize patients' residence as urban or rural, as previously described.[9] Metropolitan areas had a population of >50,000 and included RUCA codes 1, 2, 3, 4.1, 7.1, 8.1, and 10.1. Nonmetropolitan areas were defined as a population of <50,000 and included RUCA codes 4, 5, 6, 7, 7.2, 7.3, 7.4, 8, 8.2 8.3, 8.4, 9, 9.1, 9.2, 10, 10.2, 10.3, and 10.5.

Comorbidity was estimated as described by Elixhauser et al.[10] Hospital annual AAA repair volumes were converted to a five-level ordinal categoric variable. Hospitals in the lowest quintile (median, five EVARs per year) were defined as low-volume hospitals, and those in the highest quintile (median, 63 EVARs per year) were defined as high-volume hospitals.

Statistical analysis. Categoric variables, such as the characteristics of patients with complete and incomplete surveillance, were analyzed using a χ^2 test, and continuous variables were analyzed using a *t*-test for normally distributed data or a Wilcoxon signed rank test for nonparametric data. Multivariable logistic and Cox regression modeling controlling for age, sex, race, Medicaid eligibility, residential status, hospital volume, ruptured AAA (rAAA), and pre-existing comorbidities were used to determine predictors of postoperative CT, complete surveillance, and loss to follow-up.

All statistical analyses with P values of <.05 were considered significant. Statistical analyses were performed using SAS 9.1.3 software (SAS Institute Inc, Cary, NC) for data extraction and management and using STATA 13.0 software (StataCorp LP, College Station, Tex) for analysis.

RESULTS

A total of 23,964 patients underwent AAA repair between January 1, 2002, and December 31, 2005, among which 23,165 (96.7%) were aged ≥65 years during the year of repair. Among these, 22,399 (96.6%) had complete fee-for-service Medicare part A and part B coverage during year of repair. From this subpopulation, 9975 (47.2%) underwent EVAR, and 9695 EVAR patients (97.2%) survived the initial hospital stay and defined our cohort. Mean follow-up duration was 5.2 ± 2.9 years (median, 6.1 years; interquartile range, 2.6-7.4 years).

Of our cohort, 497 (5.13%) patients received no follow-up imaging. The first postoperative CT was obtained ≤30 days in 31.8% of patients, ≤45 days in 53.3%, and ≤60 days in 60.8%. The mean time to a postoperative CT was 154 ± 371 days (median, 38 days; interquartile range, 25-98 days; Fig 1). Among those with a 30-day CT, 23.0% received the CT scan during the index hospital stay.

Complete surveillance was observed in 4169 patients (43.0%; Table I). No significant difference was observed in age, sex, race, or Medicaid eligibility between patients with complete and incomplete surveillance. Patients with congestive heart failure were more likely to have complete surveillance (53.3% vs 46.7%; $P < .001$), as were those with renal failure (52.1% vs 47.9%; $P < .001$), lymphoma (63.3% vs 36.7%; $P = .004$), metastatic cancer (78.2% vs 23.8%; $P < .001$), and solid tumors (53.6% vs 46.4%; $P < .001$).

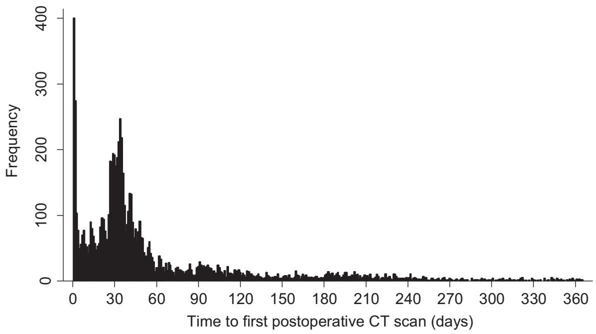

Fig 1. Distribution of time to the first postoperative computed tomography (*CT*) scan.

Table I. Characteristics of patients with complete and incomplete surveillance

Variables	*Complete (n = 4169)*	*Incomplete (n = 5526)*	P *value*
Age at repair, mean ± SD, years	76.4 ± 6.32	76.2 ± 6.25	.10
Sex, %			.16
Male	43.3	56.7	
Female	41.4	58.6	
Race, %			.09
White	42.8	57.2	
Black	48.8	51.2	
Other	42.2	57.8	
Medicaid eligible, %			.37
Yes	41.6	58.4	
No	43.2	56.9	
Residence, %			.05
Urban	43.7	56.3	
Small-town	40.3	59.7	
Rural	42.0	58.0	
Hospital volume,[a] %			<.001
High	19.5	17.1	
Medium	59.7	59.3	
Low	20.8	23.6	
Comorbidities, %			
Valvular disease	46.1	53.9	.12
Congestive heart failure	53.3	46.7	<.001
Peripheral vascular disease	44.5	55.5	.04
Hypertension	42.6	57.4	.25
Diabetes mellitus	45.3	54.7	.07
Pulmonary disease	46.2	53.8	<.001
Renal failure	52.1	47.9	<.001
Lymphoma	63.3	36.7	.01
Metastatic cancer	78.2	23.8	<.001
Solid tumor	53.6	46.4	<.001

SD, Standard deviation.
[a]Median fee-for-service Medicare endovascular aortic aneurysm repair (EVAR) yearly case volume was 5 for low-volume hospitals (range, 1-7), 20 for medium-volume hospitals (range, 8-34), and 63 for high-volume hospitals (range, 35-122).

Patients with pulmonary disease were more likely to have incomplete surveillance (46.2% vs 53.8%; $P < .001$).

Of those with incomplete surveillance, 42.5% had surveillance gaps, 36.0% were lost to follow-up, and 21.5% had gaps and were also lost to follow-up. Among those with incomplete surveillance, surveillance became incomplete at an average of 3.3 ± 1.9 years (Fig 2). In addition, total follow-up was shorter for those with complete surveillance than for those with incomplete surveillance (3.4 ± 2.7 vs 6.5 ± 2.1 years; $P < .001$). Patients with at least one gap in follow-up had a mean time of 3.1 ± 1.6 years until occurrence of the first gap. Patients were lost to follow-up at a mean of 4.6 ± 2.4 years after EVAR.

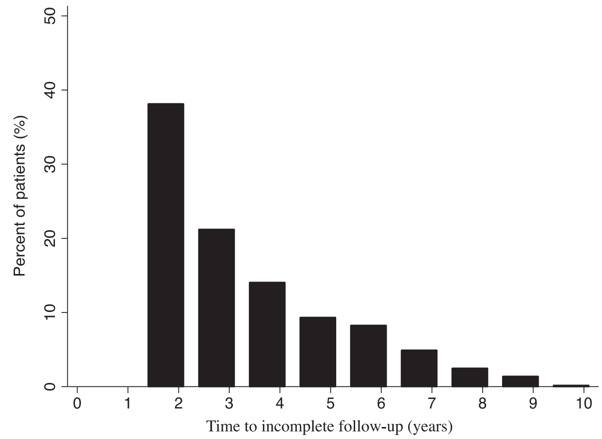

Fig 2. Distribution of time to incomplete follow-up.

A multivariable Cox regression model showed incomplete surveillance was independently associated with increasing age (hazard ratio [HR], 1.02; 95% confidence interval [CI], 1.01-1.02; $P < .001$), Medicaid eligibility (HR, 1.42; 95% CI, 1.29-1.55; $P < .001$), low-volume hospitals (HR, 1.12; 95% CI, 1.05-1.20; $P < .001$), rAAA (HR, 1.51; 95% CI, 1.24-1.84; $P < .001$), and comorbidities that might also require ongoing care (Table II). Additional analysis on loss to follow-up showed that after adjusting for patient factors, loss to follow-up was independently associated with increasing age (HR, 1.04; 95% CI, 1.03-1.04; $P < .001$), Medicaid eligibility (HR, 1.47; 95% CI, 1.30-1.65; $P < .001$), low-volume hospitals (HR, 1.16; 95% CI, 1.06-1.26; $P < .001$), and rAAA (HR, 1.63; 95% CI, 1.29-2.07; $P < .001$).

In a multivariable logistic regression model, after adjusting for patient factors, high-volume hospitals were more likely to perform the first postoperative CT scan ≤30 days (odds ratio, 1.42; 95% CI, 1.27-1.59; $P < .001$), whereas low-volume hospitals were less likely to perform the scan within the recommended interval (odds ratio, 0.85; 95% CI, 0.76-0.95; $P = .003$).

DISCUSSION

We believe this is the first study to investigate adherence to recommended postoperative surveillance guidelines after EVAR in actual practice. We found that most patients undergoing EVAR do not receive adequate surveillance as defined by the SVS. Our results showed that 5% of patients received no follow-up imaging after EVAR, ~33% were lost to follow-up, and 57% received incomplete surveillance. A main strength of our study is that it captures all surveillance

Table II. Multivariable Cox regression model for incomplete surveillance

Factor	*HR (95% CI)*	P *value*
Age	1.02 (1.01-1.02)	<.001
Male sex	1.02 (0.95-1.10)	.540
Race		
White (reference)		
Black	1.10 (0.94-1.29)	.230
Other	1.12 (0.96-1.32)	.160
Medicaid eligibility	1.42 (1.29-1.55)	<.001
Hospital volume[a]		
Medium (reference)		
Low	1.12 (1.05-1.20)	<.001
High	0.94 (0.88-1.01)	.110
rAAA	1.51 (1.24-1.84)	<.001
Congestive heart failure	1.06 (0.96-1.18)	.240
Neurologic	1.46 (1.25-1.87)	<.001
Chronic lung	1.08 (1.02-1.15)	.010
Renal failure	1.36 (1.16-1.59)	<.001
Fluid and electrolyte disorders	1.12 (1.00-1.26)	.050
Blood loss anemia	1.56 (1.20-2.03)	<.001
Deficiency anemia	1.08 (0.95-1.23)	.240
Alcohol abuse	1.52 (1.12-2.06)	.010
Psychoses	1.49 (1.01-2.19)	.040
Coagulopathy	1.19 (1.00-1.40)	.050

CI, Confidence interval; *HR,* hazard ratio, *rAAA,* ruptured abdominal aortic aneurysm.
[a]Median fee-for-service Medicare endovascular aortic aneurysm repair (EVAR) yearly case volume was 5 for low-volume hospitals (range, 1-7), 20 for medium-volume hospitals (range, 8-34), and 63 for high-volume hospitals (range, 35-122).

images after EVAR irrespective of institution or location, and therefore more accurately measures actual practice and adherence to SVS postoperative surveillance guidelines.

Our findings contrast with a single-institution study by Kret et al[6] that reported no postoperative imaging in 11% and loss to follow-up in 56% of patients. Such single-institution studies are limited because patients can relocate or receive surveillance imaging from other hospitals, thus resulting in undercapture of postoperative surveillance events. Similarly, we found lower rates of incomplete surveillance compared with studies that analyzed data from a registry as part of a clinical trial.[8] These findings reinforce these investigators' conclusions that the external validity of such clinical trial studies for surveillance guidelines may be questionable because they do not reflect actual practice.[7]

Understanding the barriers to appropriate surveillance after EVAR is paramount to offering EVAR to the right patients.[7] The SVS guidelines recommend that patients at risk for poor compliance with postoperative surveillance be identified and advised against EVAR for AAA repair. We have found that hospital-level factors, previously unidentified, may be more important in predicting incomplete surveillance. We found that undergoing EVAR at a hospital with a high AAA volume was independently associated with complete surveillance, whereas undergoing EVAR at a low-volume hospital was associated with loss to follow-up and incomplete surveillance.

Previously, Sarangarm et al[11] hypothesized that the Veterans Affairs effectively maintains excellent postoperative follow-up with patients after EVAR because of its rigorous methods such as electronic appointment tracking and travel vouchers. Thus, it is possible that hospitals with better care coordination and abundant resources, such as high-volume centers, are able to maintain better follow-up with patients and encourage adequate surveillance after EVAR.[6] Our study is the first to show that hospital-level factors are strong predictors of completeness of surveillance after EVAR. Our data help support previous literature that performing EVAR at high-volume centers yields better outcomes.[12,13]

Our examination of geographic factors found that having a rural or small-town residence impeded receiving complete surveillance. These findings are consistent with previously published studies that evaluated the association of the distance of a patient's residence from the hospital and the likelihood of follow-up after EVAR. Although Sarangarm et al[11] hypothesized that patients who lived close (<100 miles from hospital) would have better compliance, they found that patients who lived near and far both had a similar length of follow-up. Similarly, Kret et al[6] also grouped patients into three categories by distance from hospital (≤60 miles, 60-120 miles, and >120 miles) and found that median follow-up time did not differ significantly across the groups ($P = .52$). Moreover, because rural patients have been shown to be more likely to have an EVAR at a high-volume hospital,[9] this trend may wash out the independent effect of patients' rural and small-town residence on completeness of surveillance. Thus, taken together, geographic factors may not be contributing to the completeness of surveillance.

In addition to geographic and hospital-level factors, we found that having an rAAA was independently associated with loss to follow-up and a trending independent association with incomplete surveillance (Table II). We hypothesize that because patients with poor preoperative surveillance are more likely to present with an rAAA,[14] these same patients may be at risk for gaps in postoperative surveillance as well. Some studies have suggested that EVAR for rAAA is associated with improved survival,[15,16] whereas others have not shown a reduction in early mortality.[17,18] Nevertheless, developing systems of postoperative care to address the needs of this specific population may be important.

We found that a variety of preoperative comorbidities, such as congestive heart failure, chronic lung disease, renal failure, and cancer, were independently associated with complete surveillance. We hypothesize that patients with other medical conditions requiring ongoing care are more likely to return for follow-up for their chronic diseases and, thus, may be more likely to receive follow-up imaging for their EVAR. This is especially true for patients with cancer, because they may have received imaging primarily for reasons other than their EVAR. These observations contrast with other studies[6] that found no association between patient demographics or comorbidities and completeness of surveillance and are consistent with investigations by Leurs et al[8] that found hyperlipidemia and smoking status were predictive of better follow-up.

Our study is subject to certain limitations due to the nature of administrative data. As with all studies using administrative data, we were unable to collect clinical information, such as presence or absence of endoleak, and other clinical conditions that might have prompted postoperative imaging. As such, we cannot determine if surveillance gaps, as defined by the SVS guidelines, were based on clinical parameters or were simply a consequence of poor follow-up.

Furthermore, administrative data may be subject to errors or variability in coding that would skew our results.[19] However, coding errors are unlikely for hospitalizations involving serious medical conditions or major surgical procedures, or both, such as EVAR.[20,21] In addition, previous work has validated the use of Medicare data as a useful tool for capturing AAA treatment procedures.[22] Moreover, although our data set is limited in that only Medicare beneficiaries are included, it may be most suitable for studying AAA and EVAR because >70% of elective AAA repairs are among the U.S. Medicare population.[23]

CONCLUSIONS

Postoperative imaging after EVAR is highly variable in the Medicare population, and less than half of patients meet current surveillance guidelines. Although a few single-institutional studies have not shown improved outcomes with complete surveillance,[6,8] additional larger studies are necessary to determine if variability in postoperative surveillance affects long-term outcomes in the Medicare population.

AUTHOR CONTRIBUTIONS

Conception and design: TG, LB, MM
Analysis and interpretation: TG, LB, MM
Data collection: TG, MM
Writing the article: TG
Critical revision of the article: LB, MM
Final approval of the article: TG, LB, MM
Statistical analysis: TG, MM
Obtained funding: LB
Overall responsibility: MM

REFERENCES

1. Landon BE, O'Malley AJ, Giles K, Cotterill P, Schermerhorn ML. Volume-outcome relationships and abdominal aortic aneurysm repair. Circulation 2010;122:1290-7.
2. Greenhalgh RM, Brown LC, Kwong GP, Powell JT, Thompson SG. Comparison of endovascular aneurysm repair with open repair in patients with abdominal aortic aneurysm (EVAR trial 1), 30-day operative mortality results: randomised controlled trial. Lancet 2004;364:843-8.
3. Prinssen M, Verhoeven EL, Buth J, Cuypers PW, van Sambeek MR, Balm R, et al. A randomized trial comparing conventional and endovascular repair of abdominal aortic aneurysms. N Engl J Med 2004;351:1607-18.
4. Schermerhorn ML, O'Malley AJ, Jhaveri A, Cotterill P, Pomposelli F, Landon BE. Endovascular vs. open repair of abdominal aortic aneurysms in the Medicare population. N Engl J Med 2008;358:464-74.
5. Chaikof EL, Brewster DC, Dalman RL, Makaroun MS, Illig KA, Sicard GA, et al. SVS practice guidelines for the care of patients with an abdominal aortic aneurysm: executive summary. J Vasc Surg 2009;50:880-96.
6. Kret MR, Azarbal AF, Mitchell EL, Liem TK, Landry GJ, Moneta GL. Compliance with long-term surveillance recommendations following endovascular aneurysm repair or type B aortic dissection. J Vasc Surg 2013;58:25-31.
7. Jones WB, Taylor SM, Kalbaugh CA, Joels CS, Blackhurst DW, Langan EM 3rd, et al. Lost to follow-up: a potential under-appreciated limitation of endovascular aneurysm repair. J Vasc Surg 2007;46:434-40; discussion: 440-1.
8. Leurs LJ, Laheij RJ, Buth J; EUROSTAR Collaborators. What determines and are the consequences of surveillance intensity after endovascular abdominal aortic aneurysm repair? Ann Vasc Surg 2005;19:868-75.
9. Mell MW, Bartels C, Kind A, Leverson G, Smith M. Superior outcomes for rural patients after abdominal aortic aneurysm repair supports a systematic regional approach to abdominal aortic aneurysm care. J Vasc Surg 2012;56:608-13.
10. Elixhauser A, Steiner C, Harris DR, Coffey RM. Comorbidity measures for use with administrative data. Med Care 1998;36:8-27.
11. Sarangarm D, Knepper J, Marek J, Biggs KL, Robertson D, Langsfeld M. Post-endovascular aneurysm repair patient outcomes and follow-up are not adversely impacted by long travel distance to tertiary vascular surgery centers. Ann Vasc Surg 2010;24:1075-81.
12. Dimick JB, Upchurch GR Jr. Endovascular technology, hospital volume, and mortality with abdominal aortic aneurysm surgery. J Vasc Surg 2008;47:1150-4.
13. Dimick JB, Cowan JA Jr, Stanley JC, Henke PK, Pronovost PJ, Upchurch GR Jr. Surgeon specialty and provider volumes are related to outcome of intact abdominal aortic aneurysm repair in the United States. J Vasc Surg 2003;38:739-44.
14. Mell MW, Baker LC, Dalman RL, Hlatky MA. Gaps in preoperative surveillance and rupture of abdominal aortic aneurysms among Medicare beneficiaries. J Vasc Surg 2014;59:583-8.
15. Edwards ST, Schermerhorn ML, O'Malley AJ, Bensley RP, Hurks R, Cotterill P, et al. Comparative effectiveness of endovascular versus open repair of ruptured abdominal aortic aneurysm in the Medicare population. J Vasc Surg 2014;59:575-82.
16. Starnes BW, Quiroga E, Hutter C, Tran NT, Hatsukami T, Meissner M, et al. Management of ruptured abdominal aortic aneurysm in the endovascular era. J Vasc Surg 2010;51:9-17; discussion: 18.
17. IMPROVE Trial Investigators, Powell JT, Sweeting MJ, Thompson MM, Ashleigh R, Bell R, Gomes M, et al. Endovascular or open repair strategy for ruptured abdominal aortic aneurysm: 30 day outcomes from IMPROVE randomised trial. BMJ 2014;348:f7661.
18. van Beek SC, Conijn AP, Koelemay MJ, Balm R. Editor's Choice—endovascular aneurysm repair versus open repair for patients with a ruptured abdominal aortic aneurysm: a systematic review and meta-analysis of short-term survival. Eur J Vasc Endovasc Surg 2014;47:593-602.
19. Finlayson EV, Birkmeyer JD, Stukel TA, Siewers AE, Lucas FL, Wennberg DE. Adjusting surgical mortality rates for patient comorbidities: more harm than good? Surgery 2002;132:787-94.
20. Kiyota Y, Schneeweiss S, Glynn RJ, Cannuscio CC, Avorn J, Solomon DH. Accuracy of Medicare claims-based diagnosis of acute myocardial infarction: estimating positive predictive value on the basis of review of hospital records. Am Heart J 2004;148:99-104.
21. Quan H, Parsons GA, Ghali WA. Validity of procedure codes in International Classification of Diseases, 9th revision, clinical modification administrative data. Med Care 2004;42:801-9.
22. Mell MW, Pettinger M, Proulx-Burns L, Heckbert SR, Allison MA, Criqui MH, et al. Evaluation of Medicare claims data to ascertain peripheral vascular events in the Women's Health Initiative. J Vasc Surg 2014;60:98-105.
23. Schermerhorn ML, Bensley RP, Giles KA, Hurks R, O'Malley AJ, Cotterill P, et al. Changes in abdominal aortic aneurysm rupture and short-term mortality, 1995-2008: a retrospective observational study. Ann Surg 2012;256:651-8.

Submitted May 12, 2014; accepted Jul 3, 2014.